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(71) Applicant *(for all designated States except US)*: **HASBRO INTERNATIONAL, INC.** [US/US]; 1027 Newport Avenue, P.O. Box 1059, Pawtucket, RI 02862-1059 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **HART, Alan** [GB/GB]; 352 Mill Road, Cambridge CB1 3NN (GB). **CAUWOOD, Peter** [GB/GB]; 32 Greenside, Waterbeach, Cambridge CB5 9HP (GB). **LAITENBERGER, Peter** [GB/GB]; 23 Herbert Street, Cambridge CB4 1AG (GB). **FEARIS, Paul** [GB/GB]; 43 Bosworth Road, Cambridge CB1 8RG (GB). **MERINO, Darrell** [US/US]; 35 Stonehill Road, East Longmeadow, MA 01028 (US). **ROACH, Alan, Patrick** [US/US]; 4 Blueberry Hill Road, Wilbraham, MA 01095 (US).

(74) Agent: **GILL JENNINGS & EVERY**; Broadgate House, 7 Eldon Street, London EC2M 7LH (GB).

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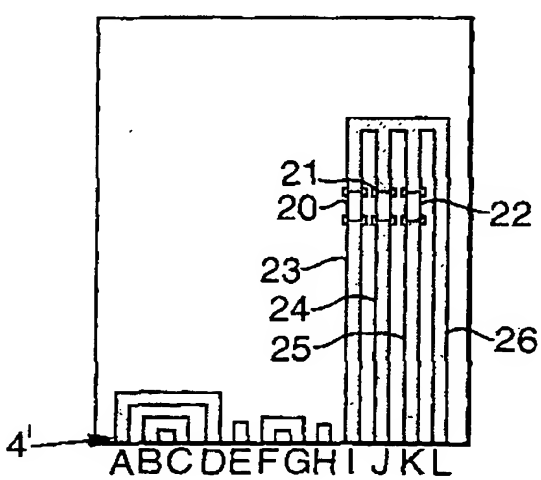
(54) Title: DATA STORE AND DATA STORE OPERATING APPARATUS



(57) **Abstract:** A data store comprises a substrate (1); and a number of separately activatable heating and data storage elements (20-22) supported by the substrate (1). Activation of a heating element (20-22) causes a material on or in the substrate in the vicinity (32A-32C) of that heating element to exhibit a change in visual character.

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DATA STORE AND DATA STORE OPERATING APPARATUS

The invention relates to a data store and to data store operating apparatus, for enabling data to be stored in a data store and/or to be read from a data store.

The invention is particularly concerned with portable data stores and a number of such data stores are known. Examples include smart cards, which include an integrated circuit chip, magnetic stripe cards, cards with substrates carrying bar codes, floppy discs, CD ROMs etc. Smart cards are relatively expensive and not well suited for high volume, low cost applications. It is also only possible with these cards to determine the data stored on the card by using sophisticated card reading equipment. Similarly, magnetic stripe cards and the use of bar codes do not solve the problem of ease of determination of the data which has been stored.

In accordance with a first aspect of the present invention, a data store comprises a substrate; and a number of separately activatable heating and data storage elements supported by the substrate, whereby activation of a heating element causes a material on or in the substrate in the vicinity of that heating element to exhibit a change in visual character.

We have designed a new type of data store which can be implemented at low cost and whose appearance can be changed, for example when data is stored.

Each element may be separately activated, and each may be a heating element, a data storage element, or may combine both these functions in a single element.

The invention has a particular application in game playing as will be explained in more detail below. However, the invention is also applicable to a variety of other applications with any of the following characteristics:

Require an inexpensive item such as a card to store data and display information.

- Require strong visual appeal.
- Require reader/writer devices to be low-cost, mobile or numerous (because the reader/writer for the invention can be relatively low in cost and power consumption).
- Require a data store which can also display temporary information (because use of reversible thermochromic materials permit this unusual characteristic).
- Entail a token which can become less valuable with use (such as a telephone card), or become more valuable with use (such as a lottery ticket); or applications which have weak anti-tamper requirements (because it will generally be possible to tamper with the card by blowing fuses).

Specific examples of applications include admission tickets; medical or other records; evidential documents such as medical prescriptions; competition entry tickets; employee time clock record systems; store or company loyalty cards; metered payment systems; licence documents; transport tickets.

In order to activate the heating and data storage elements, it is necessary to transfer power to those elements, and conveniently this is achieved by providing a set of electrical contacts connected to the heating and data storage elements to enable the heating and data storage elements to be connected to remote electronics. However, it would also be possible to transfer information and power via non-contact, inductive methods known in the art.

In some versions of the invention, additional electrical contacts are provided in order to permit the data store to contain permanent "read-only" information. Some of these "Additional Connections" are electrically interconnected within the data store, and the different interconnection patterns are used to represent different information states, as will be explained in more detail below.

Conveniently, the heating and data storage elements are each connected to a pair of the electrical contacts via electrical conductors on or in the substrate. Typically, at least one of the electrical conductors is common to more than one heating and data storage element. However, if space permits, separate pairs of conductors could be connected to each heating and data storage element.

We have found that the electrical contacts and/or electrical conductors can be screen or offset printed onto the substrate using conductive inks, which leads to ease and low cost of manufacture. Offset printing will be referred to hereafter but other processes may be used such as foil stamping, ink jet printing, litho, oil-ablation, hot-foil printing, hand painting and the use of thin metal wires laminated in or to the substrate.

Each data storage element preferably comprises an electrical fuse which will be "blown" when it records a data value. Again, these fuses can conveniently be printed on the substrate. The "blowing" of the fuse may occur via a variety of physical mechanisms, such as by thermal expansion or contraction of components of the data store, causing a rupture of the conductive track forming the fuse, or by thermal damage to the conductive tracks themselves (by oxidation or phase change, for example). These data values are thus preferably binary. Some fuses could be preblown during manufacture, depending upon the application.

In one approach, each heating element is separate, and separately activatable, from each data storage element. This allows full flexibility in which element is activated, but has the drawback that in cases where a large number of elements are required, there may be a lack of space to provide them.

In a second, preferred approach, respective pairs of heating and data storage elements are formed by a common element. Thus, a single fuse can act both as a data storage element and as a heating element. In a simple

preferred embodiment, the fuse functionality is achieved by driving a sufficient current through the combined element to cause a part of it to rupture. In such an embodiment, the heater will no longer function after such a rupture.

Typically, the material will exhibit an irreversible visual change when heated. Such behaviour is desirable when a quasi-permanent record of an event is needed - for example, in game applications, the recording of a victory; or in ticketing applications, recording that the ticket has been used.

In other situations, a reversible visual change is desirable, to provide a temporary indication. In applications where such capability is required, a material which exhibits a reversible visual change with temperature may be used. This would be particularly useful in game playing applications, where a temporary effect is required, such as an indication that the game player associated with the store is entitled to throw a ball onto a pitch in a soccer game or the like, or an indication that the card is "live" and in use. More than one such material could be included to allow a variety of different effects to be achieved at different parts of the data store substrate.

In a variant of the invention, multiple visual changes may be driven by a single heater. A first example of how this may be achieved is the use of multiple reversible or irreversible materials with different operating temperatures but deposited intermingled or in a single location. In a second example, a reversible leucodye is driven beyond a critical temperature, above which the material becomes altered and it adopts a new, permanent visual state. These techniques achieve an economy of space and of connection requirements.

The preferred change is a colour change. We have reviewed various materials which are suitable, and the preferred material is a thermochromic material such as an ink, paint, dye, pigment, masterbatch blend, or other thermochromic coating. The term "thermochromic masterbatch

blend" describes the situation where a thermochromic additive (the aforementioned masterbatch blend) is added to a bulk polymer which is then used during manufacture, for example in a plastic film.

The shape of the material in the vicinity of each heating element can be chosen in accordance with the application concerned. Typically, at least one region of the substrate which exhibits a visual change defines a character shape and in some cases, the regions may cooperate together to form a composite character. Characters and character shapes such as alphanumeric characters, pictures, symbols, logos and the like are envisaged. Shapes may also include obscuring features that become transparent when activated, revealing previously hidden features. A reversible leucodye is a suitable material. Thus the change in visual characteristic may be a colour change or a change from opaque to transparent or vice versa. The regions may also define other non-character shapes such as blocks denoting a number of winning or losing conditions.

The data store is conveniently fabricated as a card, and can be produced in a wide variety of dimensions. In one example the data store has standard credit card or playing card dimensions, making it easy to handle and store and suitable for collection by game players in game applications. In other situations, it may be appropriate to fabricate much larger or smaller devices: for example, where the data store is part of an exhibition ticket or licence document.

The technology is applicable to a broad variety of substrate media. Preferred examples include paper, card, polyester and cellulose acetate.

The data store can simply be provided with the heating and data storage elements as mentioned above. However, the store can be additionally provided with one or more of an additional magnetic stripe, a magnetic tagging technology such as Flying Null, an integrated circuit, or a low-power

static display (examples include rewritable magnetic ink displays available from Star Micronics, bistable rewritable thermochromic systems now used in loyalty cards from manufacturers such as Panasonic, and the so-called "electronic ink" systems developed by Xerox (Gyricon) and E-Ink (Immedia)). In addition, although the data store is preferably not self-powered, the store could include a power source such as a thin and flat source, for example a lithium-polymer or lithium-ion battery, a photovoltaic material or a super capacitor. Some data stores may include an electro-mechanical input device such as a dome clicker, piezo film, or low cost conductive pressure switch. An example of a low-cost conductive switch is the battery tester now frequently included on the exterior of consumer batteries.

In order to use the data store, we provide in accordance with a second aspect of this invention, data store operating apparatus comprising a processor, a power transfer coupler for coupling with a data store according to the first aspect of the invention and for supplying power selectively to one or more of the heating and data storage elements of the data store under control of the processor.

The apparatus could be constructed so as to carry out one or more than one of the following operations:

i) read data from the data store;

ii) write data to the data store; or

iii) activate a heating element in the data store.

Preferably, the apparatus is constructed to perform all three functions.

Typically, the apparatus will further comprise an input device to which the processor is responsive to store data in the data store. The input device could be used to supply the data which is to be stored, but, for example in the case of a game application, could be used by the player to play the game, the data itself being generated by the processor.

In a preferred embodiment, the apparatus further comprises a display for displaying information related to data stored in the data store.

In some examples, the apparatus comprises a second power transfer coupler, the processor also responding to data stored in a data store connected to the second coupler. This enables two-player games to be implemented with typically each data store defining the capability of each player as part of the game playing scenario.

Some examples of data stores and data store operating apparatus will now be described with reference to the accompanying drawings in which:-

Figure 1 is a schematic plan of a first example of a data card with some parts omitted for clarity;

Figure 2 is a schematic cross-section through an overlaminate for use with the data store shown in Figure 1;

Figures 3A and 3B illustrate the fuse and track arrangement and the outer appearance of a second example of a card according to the invention, respectively;

Figure 4 is an example of an interconnectivity matrix;

Figures 5A and 5B are a perspective view and a block diagram respectively of a game pod for use with data stores according to the invention;

Figures 6 and 7 are schematic block diagrams of two reading/writing circuits;

Figure 8 is a schematic circuit diagram of a circuit for sensing interconnectivity of additional connections of a card;

Figures 9A and 9B illustrate the outer appearance of another example of a card before and after use respectively;

Figures 10A and 10B are a partially cut away portion and a view of the outer appearance of the portion shown in Figure 10A respectively of part of the card shown in Figure 9;

Figures 11A and 11B illustrate examples of heaters;

Figures 12A-12E illustrate further examples of heaters; and,

Figure 13 is a schematic plan of a further example of a fuse arrangement.

Although there are a variety of ways in which the invention can be implemented, these can generally be grouped into two categories. First, in which the fuses and heaters are integrated into combined or common elements, and second in which the fuses and heaters are separate elements. Of course, hybrids of these are also possible.

Figure 1 illustrates an example of a data store of the second category.

The data store shown in Figure 1 has dimensions corresponding to, but not limited to, a typical playing card (about 9 x 6cm), and comprises a polyester substrate 1 on which are offset printed a first array of low resistance conductive tracks 2A,2B connected via fuses 2C. A second array of low resistance conductive tracks 2D,2E are printed adjacent the first set and are connected via respective heaters 2F; and a third array of low resistance conductive tracks 2G,2H are printed adjacent the second array with sets of heaters 2I extending between them.

All the tracks 2A-2I are made of a single conductive ink such as silver loaded ink and, as will be seen, the fuses 2C and heaters 2F,2I are separate. A possible fuse construction for each fuse 2C is a weak link shown in the inset in Figure 1.

The array of conductors 2G-2I define multiple heaters which together form a large area heater.

The heaters 2F,2I can be constructed in a variety of ways, two of which are shown in Figure 11. Figure 11A illustrates a serpentine track 2K extending between primary tracks 2E,2D. The resistance of each heater can be optimized by varying the track width and length and adjusting the thickness of the conducting layer.

Figure 11B illustrates a carbon loaded ink 2J bridging the gap between the tracks 2E,2D.

Each of the arrays of conductors 2A,2B and 2D,2E have a common electrode 2A,2B respectively together with a set of individual electrodes 2D,2E. This enables each fuse 2C and/or heater 2F to be individually activated.

The other end of each conductor 2A-2G terminates at respective contacts 4 extending along one edge of the card.

A thin laminate overlay 6 (Figure 2) is laminated to the substrate 1 following deposit of the conductors 2A-2I by passing the two components 1,6 between heated laminating rollers. The overlay 6 comprises a transparent film 7, of for example polyester, onto which is printed individual thermochromic regions 8, such as a thermochromic ink, corresponding to the different heaters 2F,2I, and elsewhere full colour inks 9 defining graphics typically depicting game characters and/or other information relating to the activity with which the card is associated.

The thermochromic regions 8 will also be printed in the shapes of characters, numerals or the like as appropriate. Typical areas for the heating regions 8 range from 3mm^2 to 250mm^2. For the smaller areas, currents as low as 70mA could be used to achieve a rapid (100ms to 1s) colour change, while for the larger area current of about 1.5A at a supply voltage of 5V for about 15 seconds produces the colour change.

The printed transparent film 7 is then back printed with a white ink 10A and overlaid with an adhesive layer 10B, following which it is laminated to substrate 1 under moderate pressure.

A variety of thermochromic inks could be used in the regions 8, but leucodyes are preferred. A further advantage of many thermochromic inks is that they can be reversibly heated. That is, they will exhibit a colour change on heating, but this colour change will revert on cooling. This leads to the possibility of temporary displays of information, particularly suitable for game playing applications.

In this example, the conductive tracks 2A-2I are offset printed onto the substrate 1, although other methods could be used, such as lamination of fine wires into a suitable substrate, as mentioned above. Both offset printing and also screen printing have several advantages. These technologies are compatible with conventional card manufacture and can be readily adapted to different sizes and shapes of heaters.

The network of fuses 2C can be pre-programmed so as to define the character of the card, and/or can be programmable using a game pod of the type described below in connection with Figure 5A.

In this example, the fuses 2C are realised by reducing the track width and/or thickness to produce a weak link at the desired location. This link can then be broken using a suitable current pulse generated by electronic drive circuitry in the card reader/writer apparatus.

Other techniques for manufacturing the fuses are mentioned above. The fuse can be anything that can be caused to undergo a permanent resistance change by exceeding a specific electrical current for a certain duration. Examples include foil, printed or painted coatings and metal wires.

In the preferred arrangement shown in Figure 1, the fuses are connected in a planar array to respective electronic drivers (in the reader/writer apparatus) using one connecting pin or contact for each fuse and a common pin or contact to provide a current return path. As an alternative, it is possible to arrange fuses in a two dimensional matrix array, when the number of drivers required is the number of rows plus the number of columns. This would only require 20 drivers for a 10x10 array, but would additionally normally require the use of a blocking diode in series with every fuse and thus this approach is less preferred. Blocking diodes are not strictly necessary for the function of a two-dimensional matrix, but without them, parallel conduction paths exist through the matrix.

In this circumstance, the functioning of the matrix becomes critically dependent on the accuracy of the resistances of the unblown fuses, whose resistance must therefore be specifiable within very narrow tolerances. For this reason, a preferred embodiment for this cost-optimised system is a planar matrix.

Fuses are blown by driving a current through them in a predetermined way - either by monitoring the fuse resistance until it changes in a known way - typically an increase of resistance; or simply by using a known and well characterised current pulse. Fuse status may be tested by measuring fuse resistance, using one of the well-known techniques for measuring resistance.

As an alternative to the example shown in Figures 1 and 2, the fuses and heating regions can be combined. Figure 11 illustrates at 2D' a modified track with a weakened section defining a fuse. Figures 3A and 3B illustrate an example using combined heaters and fuses. Figure 3A depicts the track layout of a card featuring three combined heater/fuse elements 20-22 connected via respective electrically conductive tracks 23-25 and a common track 26 to connections I-L respectively and eight Additional Connections A-H forming a set of contacts 4'.

The combined heater/fuse elements 20-22 can be fabricated in a variety of ways, some of which are shown in Figure 12. Figure 12D illustrates a heater/fuse element of the type shown in Figure 3A, the tracks 23,26 defining a gap between their ends which is bridged by carbon loaded inks 27A. When a current is passed through the material 27A, it will heat causing an adjacent thermochromic material to change colour. If it is then driven with a higher current and/or for a longer time, this will cause expansion or contraction of the component materials and hence rupture of the heater equivalent to the blow out of a fuse.

Figure 12C illustrates an alternative heater constructed using a silver loaded or similar ink having a

serpentine configuration 27B as described above in connection with Figure 11A. The heater 27B is driven at one level to achieve heating and hence change of colour of an adjacent thermochromic material and with a higher current and/or for a longer time to cause damage to the heater 27B.

In another version (Figures 12B and 12E), a heater of the type shown in Figure 12C or 12D can be provided with a weak link 27C formed in one of the tracks 23 to define a fuse.

In a further alternative (Figure 12A), a weak link 27D is formed in a serpentine heater 27B.

The card will be overlaminated with thermochromic regions as before. Figure 3B shows how this card might appear outwardly to the user. In this example it features a pre-printed illustration 30 and text 31, and three thermochromic display elements 32A-32C. Two of the elements, 20,22 behind the thermochromic elements 32A,32C have been operated, revealing the numbers "1" and "5".

Additional Connections A-H are provided on the card, over and above those required for the operation of fuses and heaters. The Additional Connections can be permanently electrically connected to each other in a variety of combinations using the same interconnect technology used for the rest of the card. The card reader/writer device or game pod will contain an algorithm to translate this pattern into an identifying number code. These Additional Connections and hence the number code are used to represent permanent information pertaining to the card. For example, if the cards are used to represent characters in a game, these Additional Connections can be used to represent Character Identification information, readable by the card reader/writer device, that is permanent to the character which the card represents.

The pattern of interconnections may be algorithmically converted into a unique identifying number code by a variety of methods. We now describe one preferred method by

which this algorithmic conversion may be achieved, to illustrate that this is a straightforward process. It is self-evident to those skilled in the art that many other software and electronic methods could be employed to this end.

Figure 4 shows how a matrix of digits one and zero may be populated to represent the interconnection pattern of the card's Additional Connections. In Figure 3, Connections E and H are not connected to any other card connections. By contrast, connection A is wired to D, B to C, and F to G. These three interconnections correspond to the three nonzero digits in Figure 4, in which the digit "1" indicates a "connected" state, and "0" a "not connected" state.

The digits may be read out of the matrix to form a binary number using an agreed procedure, thus:

0010000100000000000000000100

Each such number represents a combination of interconnections of the additional connectors of the card. For a card with N Additional Connections, this binary number has N(N-1)/2 digits or "bits", as is apparent from an examination of Figure 4. This procedure applies irrespective of the value N.

Many such N(N-1)/2 digit binary numbers do not represent valid interconnection patterns. For example, if A is connected to B, and B to C, A must also be connected to C; yet binary numbers could be constructed to represent the impossible situation where A is connected to B, and B to C, but A is not connected to C.

A device reading the interconnectivity pattern of these Additional Connections can therefore generate algorithmically a binary number representing the pattern of interconnections. This number can then be "looked up" by a microprocessor in a table of such numbers stored in a memory device. Entries in this table provide convenient

translation between the interconnection pattern of the card and the permanent information intended to be represented by that interconnection pattern. The table will not in general contain the many binary numbers that represent impossible connection patterns - thus, the table does not contain a set of consecutive binary numbers. The table must therefore be searched in order to locate a given binary number within it. If the binary numbers are stored sorted, e.g. in order of increasing numerical value, then an algorithm such as a binary search will permit any given binary number to be located quickly within the table.

Finally, it should be noted that in a single layer fabrication scheme, not all combinations of on-card interconnections between these Additional Connections are possible because tracks cannot cross. For example, in Figure 3, Connection C cannot be connected electrically to E unless (i) D remains unconnected, or (ii) D is connected to both C and E.

Table 1 tabulates (without proof) the relationship between the number of Additional Connections and the number of interconnectivity combinations achievable using a single layer of conductor, for a number of additional connections varying from 1 to 9.

Connections	*Combinations*
1	1
2	2
3	5
4	14
5	42
6	132
7	429
8	1430
9	4862

Table 1: Relationship between number of card Additional Connections and the number of interconnection combinations that can be achieved by a single layer of interconnects.

In order to use the cards in a game application, a game pod 50 (Figure 5A) is provided containing a number of components shown in more detail in Figure 5B.

The pod 50 comprises a main processor 55 (Figure 5B) coupled to a store 56 for storing data relating to the game, including programme code, the processor also being connected to a pair of input devices 57,58 for use by players. The input devices 57,58 may be membrane switches, keypads, keyboards, joysticks, mice and the like. The processor 55 is also connected to a set of components for each player, each set comprising a LCD Display 59A,59B, a driver/reader unit 60A,60B and, via the unit 60A,60B, couplers 61A,61B. An on/off switch 52 is provided.

The game pod is mounted in a suitable housing 51 so that the two players face each other, and have available to them their own input devices 57,58 and can see their own LCD Display 59A,59B but cannot see the other player's LCD Display. In other examples (not shown), a single display with a divider to provide privacy could be used, or the rules of the game might not require separate displays.

In use, each player inserts his card 52 (only one shown), of the type shown in Figure 1 or Figure 3, into the respective coupler 61A,61B so that the contact rows 4 or 4' on the cards are engaged by corresponding contacts in the couplers. The processor 55 then operates the driver/reader units 60A, 60B so as to obtain information from the cards. This information corresponds to data about which of the fuses 20-22 have been blown and character identification information (from contacts A-H). This data is then processed in conjunction with the game programme and may, for example, indicate the level which a player has reached, the number of previous wins and the like.

The processor 55 then operates the game by displaying information on the LCD's 59A,59B and receiving information via the input devices 57,58 and from time to time, or at the end of the game, the processor will issue appropriate

signals via the units 60A,60B to the couplers 61A,61B to cause one or more additional fuses (20-22) to be blown.

In the case of a card corresponding to the Figure 3 example, the blowing of a fuse will also cause activation of the corresponding heating region (32A-32C), and a new character or other indicia will be revealed. The players will see that the appearance of the cards has changed, typically indicating their success or failure during the game play.

In the case of the Figure 1 and 2 example, the units 60A, 60B would be adapted to supply a suitable current to the heaters 2F,2I to cause the colour change, as well as separately blowing the appropriate fuses 2C.

It will be readily understood that a single input version of the game pod could be implemented in which items 58,59B,60B and 61B are not provided. Such a single-card reader/writer system would be suitable for use in non-game applications such as admissions tickets, for example in exhibitions, museums, car parks and the like. The thermochromic marks on the cards and the fuse data may indicate date and time of admission, nature of access permission and also may have promotional functions such as concealed information about prizes.

Other alternative systems include devices that dock together and accept a single data store each.

The drive circuit contained in the drive units 60A,60B to operate fuses and heaters must supply a relatively large current (approximately 80 mA to 1.5 A) and therefore requires specialised driver electronics.

This drive circuit could be implemented in a number of ways. Mentioned here are two preferred methods of implementation, which have been illustrated for a system with eight fuses/heaters. In both implementations, fuse status can be read by a comparator which measures the voltage across a sense resistor and provides a logic input to the microprocessor.

A third preferred realisation is the embodiment of the same principles in an ASIC, which can include elements such as the microprocessor, multi-channel drivers and comparator in a single integrated circuit. Those skilled in the art of electronics will perceive that many other circuit implementations are possible.

Figure 6 illustrates a first option in which a pair of 4-channel drivers 70,71 are used, each fuse 73 in the card being connected to a respective one of the drivers 71,72. The common track 74 is connected via an amplifier 75 to the microprocessor 55.

Figure 7 illustrates an alternative configuration in which a single 4-channel driver 76 is used, each port of the driver 76 being connected to a pair of fuses 73 via respective tracks and diodes 77,78. The fuses 73 are connected in groups of four to respective FETs 79,80 whose gates are controlled by the microprocessor 55.

It will be readily understood how each of these configurations (Figures 6 and 7) can be controlled to address one particular fuse 73.

In each circuit (Figures 6 and 7) the comparator 75 is connected across a current sense resistor 81 so that the voltage across the resistor can be monitored to provide a signal indicating whether the supply current is high or low. The microprocessor 55 is then programmed to apply a short pulse to each fuse 73 in turn, the pulse being too short to rupture the fuse but long enough to allow the comparator to see an increase in supply current. This then provides an indication as to whether or not the fuse being read has been blown.

In order to read the status of the Additional (combinatorial) Connections A-H described in Figures 3A and 3B, much lower current is required. These connections can be probed using a circuit such as that illustrated in Figure 8. The microprocessor 55 (or equivalent, such as part of an ASIC) is equipped with a number of individually configurable bidirectional input/output ports. A number M

of these ports are dedicated to the determination of interconnectivity of the Additional Connections. In Figure 6, M has the value 8.

The microprocessor's program is designed to ensure that at any given moment, no more than one of the M ports is configured as an output, and that the rest are configured as inputs. The microprocessor asserts a known logic level on the one output line, while pull-up or pull-down resistors ensure that the inverse logic level is present on lines not connected to this output line. For example, in Figure 8, the microprocessor asserts OV while lines not driven by the processor will be at V_s.

When the microprocessor asserts this logic level on one of the card's Additional Connections, it then senses the logic level on each of the M-1 inputs. This is then repeated for each of the reports as the output. This permits the microprocessor's program to determine the pattern of interconnectivity of the Additional Connections on the card.

Figures 9A and 9B depict the outward appearance of another example of a card before and after partial use. A number of thermochromic regions 90-95 have been activated in Figure 9B.

In Figures 10A and 10B, we illustrate cutaway and external views of the lower portion 90 of the partially used card of Figure 9B.

Figure 10A illustrates the structure of the card shown in Figure 9B. This comprises a plastic substrate 1 on which silver based ink conductive tracks 80 have been printed, each track terminating in a rectangular region 81. The regions 81 are electrically connected by a deposited resistive, carbon-based film 82 defining a fuse element. The structure defined so far is then covered with a white ink layer or opaque film 83 with an adhesive coating and then square regions 84 have been printed using a permanent coloured ink on the film 83. The square regions are in alignment with the rectangular regions 81.

Within each square region 84 a thermochromic latent image in the form of a "X" has been printed as shown at 85 and initially this is invisible as depicted by the dotted lines in Figure 10A. The printed layer 83 is then covered by a transparent film 86.

Prior to activation, the appearance of the portion shown in Figure 10A is as shown at 90 in Figure 9A while after activation of the first four thermochromic images in the regions 92-95 the area 90 has the appearance shown in Figures 9B and 10B. In addition, further regions 97 and 98 have been activated in Figure 9B.

Figure 13 illustrates schematically a further example of a card which differs from previous examples in that the card includes an on-board power supply 110 coupled via an on-board switch 112, such as a dome switch, to a fuse 114 overprinted with a thermochromic image (not shown). The fuse 114 is also connected to a pair of contacts 116,117. In this case, a separate game pod of the type shown in Figure 5A is not required for activating the fuse 114. Instead, the dome switch 112 is depressed to pass current from the battery 110 through the fuse in order to blow it or at least to cause sufficient heating to change the appearance of the thermochromic image. In order to determine a data value defined by the fuse 114 (in its blown or unblown state), the card is connected via the contacts 116,117 to a card reader. In practice, there may be a number of switches 112 and associated fuses 114 to enable a variety of images and/or data values to be stored.

CLAIMS

1. A data store comprising a substrate; and a number of separately activatable heating and data storage elements supported by the substrate, whereby activation of a heating element causes a material on or in the substrate in the vicinity of that heating element to exhibit a change in visual character.

2. A store according to claim 1, further comprising a set of electrical contacts connected to the heating and data storage elements to enable the heating and data storage elements to be connected to remote electronics.

3. A store according to claim 2, wherein the heating and data storage elements are each connected to a pair of the electrical contacts via electrical conductors on or in the substrate.

4. A store according to claim 3, wherein at least one of the electrical conductors is common to more than one heating and data storage element.

5. A store according to any of claims 2 to 4, wherein the electrical contacts and/or electrical conductors are deposited or printed on the substrate.

6. A store according to claim 5, wherein the electrical contacts and/or electrical conductors are formed from conductive ink.

7. A store according to any of the preceding claims, wherein each data storage element comprises an electrical fuse.

8. A store according to claim 7, wherein the fuses are printed on the substrate.

9. A store according to claim 8, wherein one or more of the fuses comprises a weak, electrically conductive link.

10. A store according to claim 8 or claim 9, wherein one or more of the fuses comprises a component formed from two materials which ruptures after passage of a sufficiently high and/or long duration current.

11. A store according to any of the preceding claims, wherein one or more of the heater elements comprises an electrical conductor formed in a serpentine manner.

12. A store according to any of the preceding claims, wherein one or more of the heater elements comprises a pair of conductors of one material defining a gap between their ends which is bridged by another material.

13. A store according to claim 10 or claim 12, wherein the materials comprise a silver based ink and a carbon loaded ink respectively.

14. A store according to any of the preceding claims, wherein one or more respective pairs of heating and data storage elements are formed by a common element.

15. A store according to any of the preceding claims, wherein one or more respective pairs of heating and data storage elements are formed by separately activatable elements.

16. A store according to any of the preceding claims, wherein at least two of the heating elements have different sizes so as to heat different sized regions of the substrate.

17. A store according to any of the preceding claims, wherein the material exhibits an irreversible visual change.

18. A store according to any of claims 1 to 16, wherein the material exhibits a reversible visual change.

19. A store according to any of the preceding claims, wherein the material exhibiting the visual change is one of a thermochromic ink, dye, pigment, paint, coating, and masterbatch blend.

20. A store according to any of the preceding claims, wherein at least one region of the substrate which exhibits a change in visual characteristic defines a character shape.

21. A store according to claim 20, wherein at least two of the regions cooperate together to form a composite character.

22. A store according to claim 19 or claim 20, wherein the character or character shape comprises an alphanumeric character, a picture, a symbol or logo.

23. A store according to any of the preceding claims, wherein the substrate has the dimensions of a conventional playing or collectable card.

24. A store according to any of the preceding claims, wherein the substrate is made of one of paper, card, polyester and cellulose acetate.

25. A store according to any of the preceding claims, further comprising a power source on the substrate, electronically coupled with the heating and data storage elements via one or more user actuable switches on the substrate.

26. A data store operating apparatus for storing data in a data store according to any of the preceding claims, the apparatus comprising a control system, a power transfer coupler for coupling with a data store and for supplying power selectively to one or more of the heating and data storage elements of the data store under control of the control system, so as to store data in the data store and/or read data previously stored in the data store.

27. Apparatus according to claim 26, wherein the apparatus is constructed so as to carry out one or more than one of the following operations:

i) read data from the data store;

ii) write data to the data store; or

iii) activate a heating element in the data store.

28. Apparatus according to claim 26 or claim 27, where the control system is adapted to read data previously stored in the data store and store data in the data store.

29. Apparatus according to any of claims 26 to 28, further comprising an input device to which the control system is responsive to store data in the data store.

30. Apparatus according claim 26 to 29, further comprising a display for displaying information related to data stored in the data store.

31. Apparatus according to any of claims 26 to 30, wherein the control system is adapted to control a game dependent on signals input via the input device.

32. Apparatus according to claim 31, where the control system also responds to data stored in a data store connected to the coupler.

33. Apparatus according to claim 31 or claim 32, further comprising a second power transfer coupler, the control system also responding to data stored in a data store connected to the second coupler.

34. Apparatus according to any of claims 26 to 33, wherein the control system comprises a processor.

35. Apparatus according to any of claims 26 to 34, wherein the power coupler is adapted to inductively couple with a data store.

36. Apparatus according to any of claims 26 to 34, wherein the power coupler is adapted to conductively couple with a data store.

Fig.1.

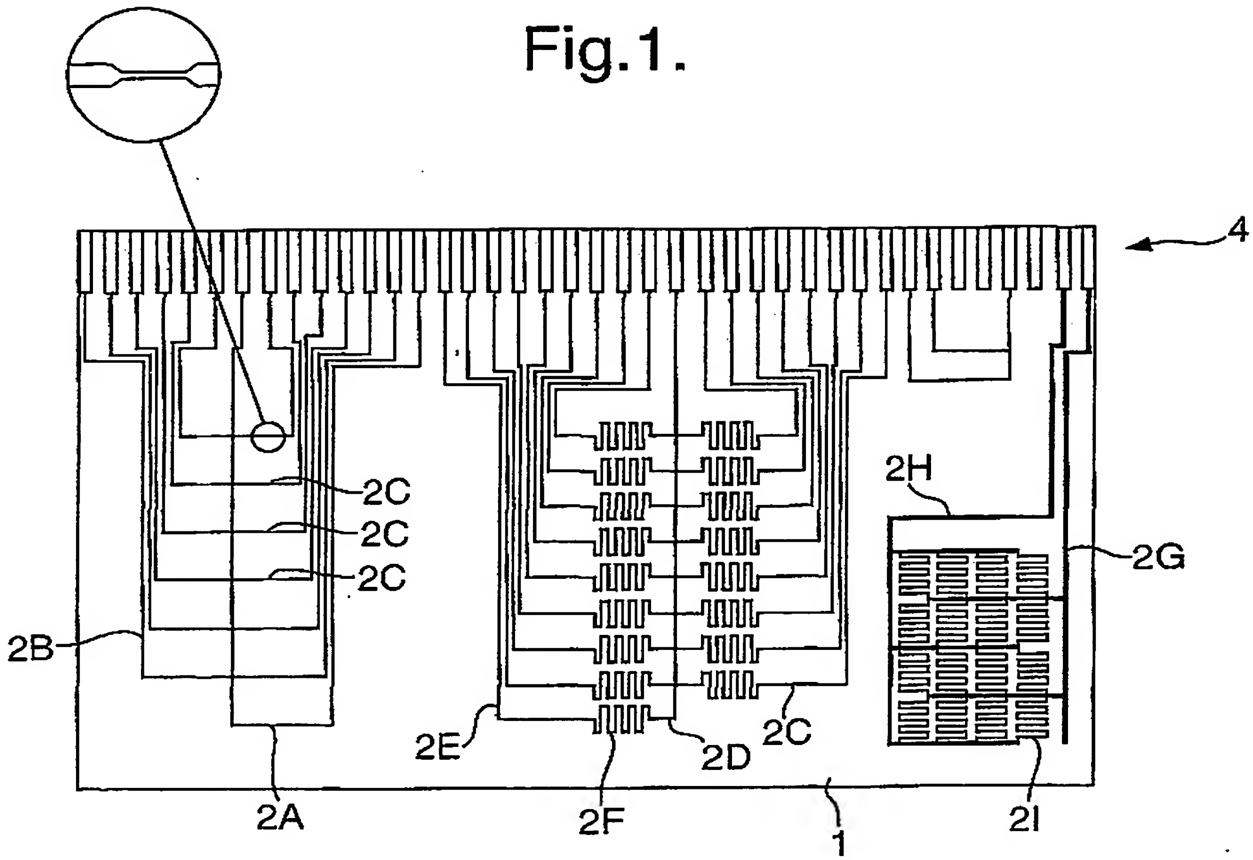


Fig.2.

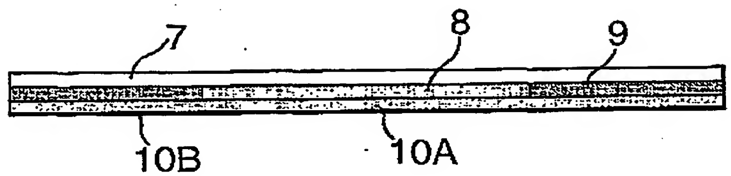


Fig.10A.

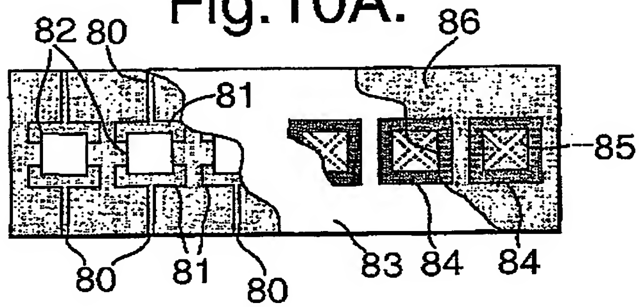


Fig.10B.

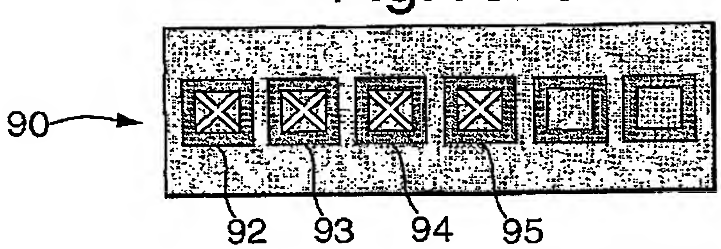


Fig.3A.

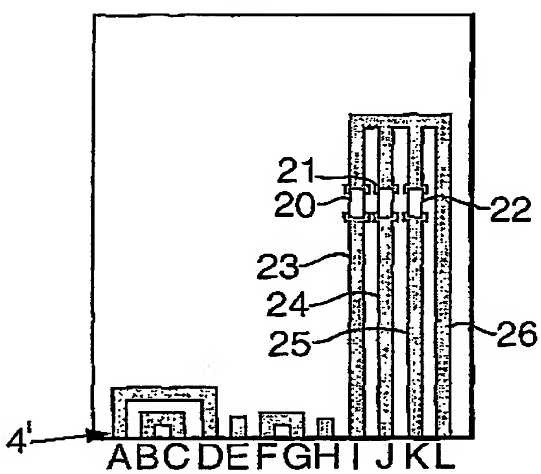


Fig.3B.

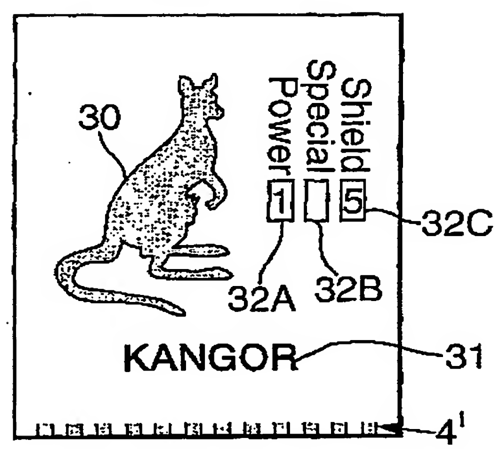


Fig.4.

Right-hand connection

Left-hand connection

	B	C	D	E	F	G	H
A	0	0	1	0	0	0	0
B		1	0	0	0	0	0
C			0	0	0	0	0
D				0	0	0	0
E					0	0	0
F						1	0
G							0

Fig.5A.

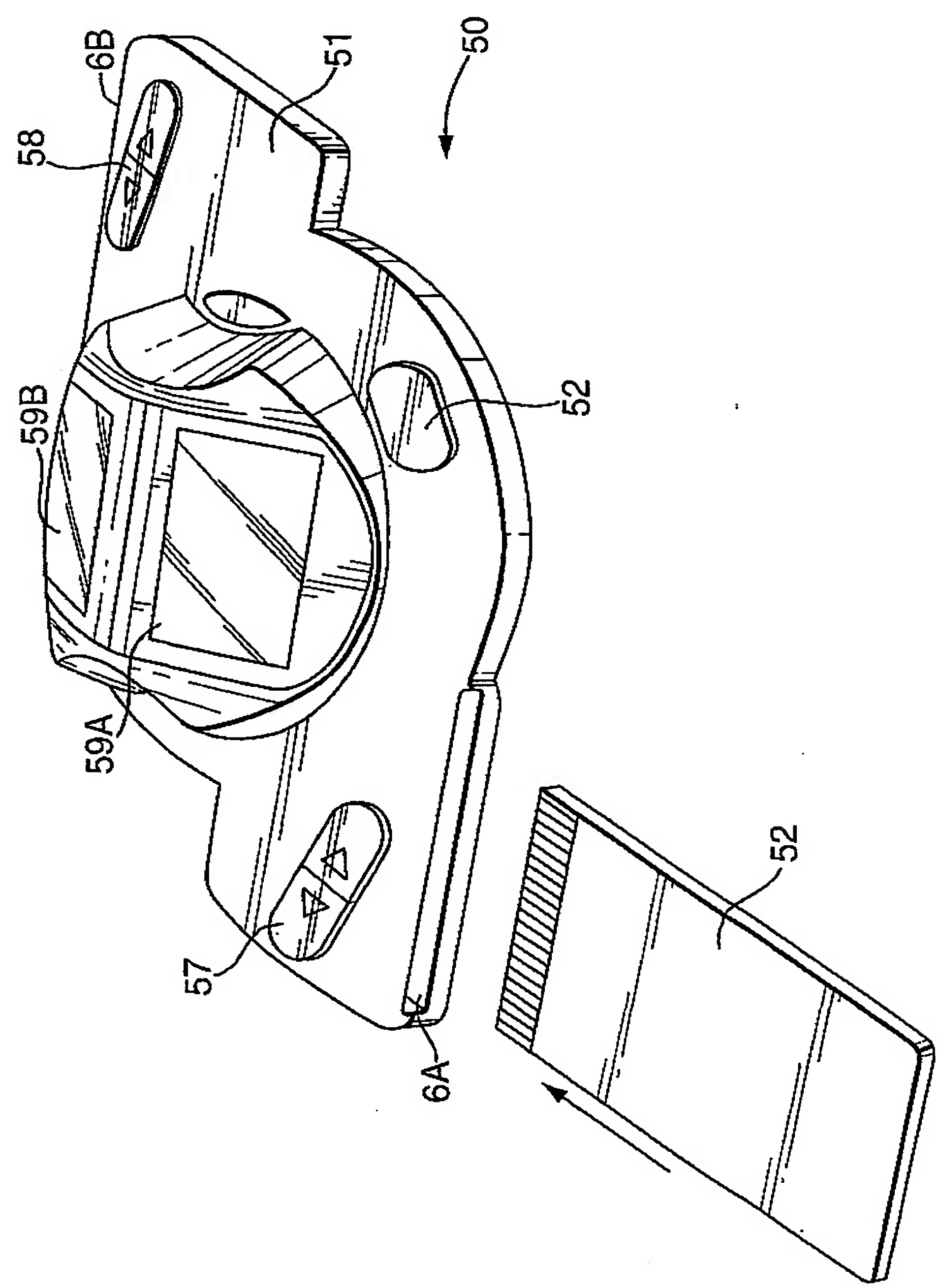
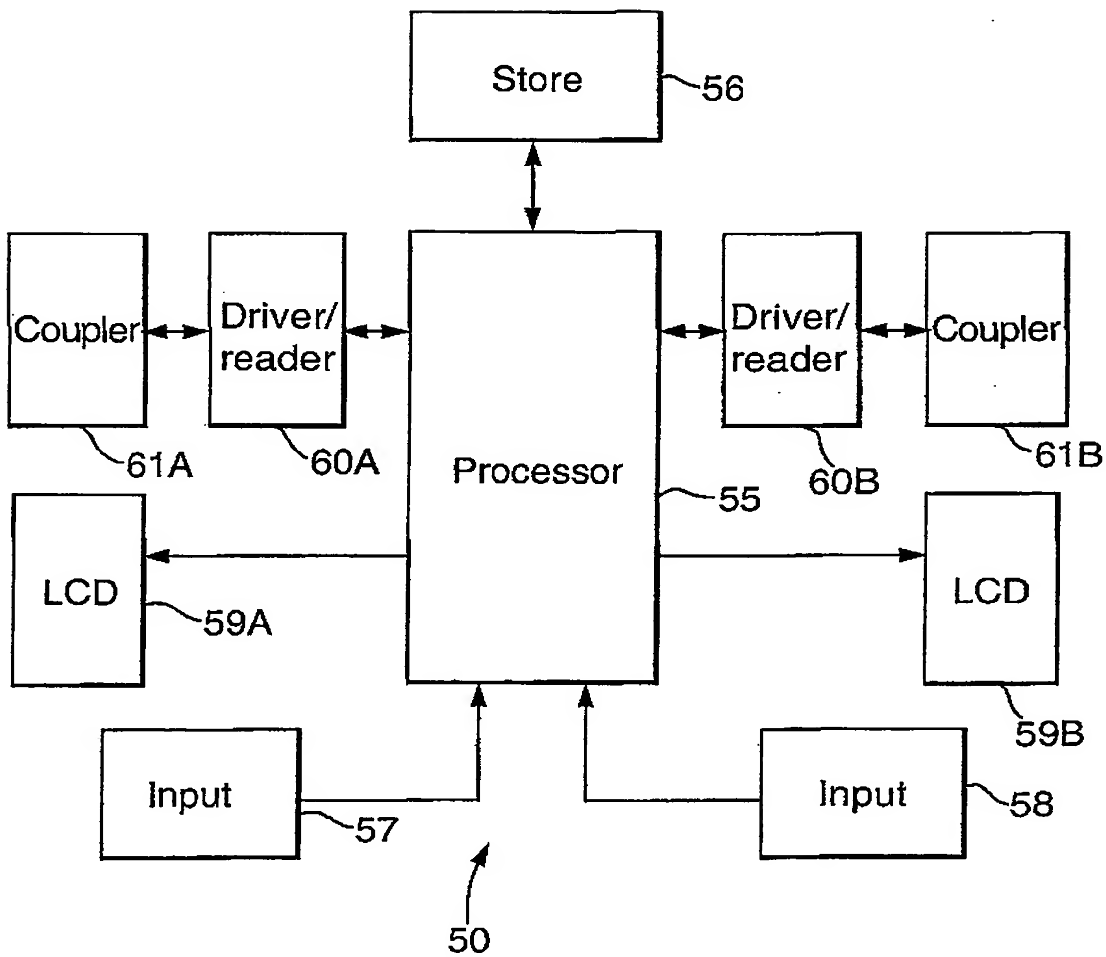


Fig.5B.


Store
56
Coupler
Driver/
reader
Processor
Driver/
reader
Coupler
61A
60A
55
60B
61B
LCD
59A
LCD
59B
Input
57
Input
58
50

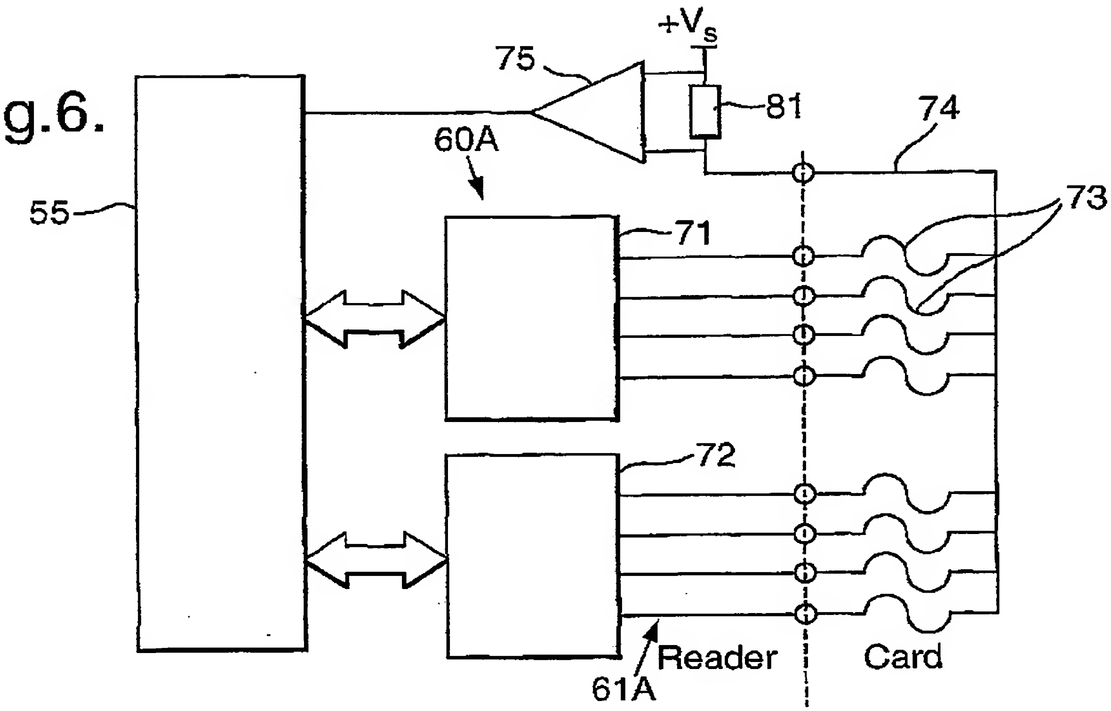

+Vs
75
81
74
60A
73
55
71
72
Reader
Card
61A

Fig.6.

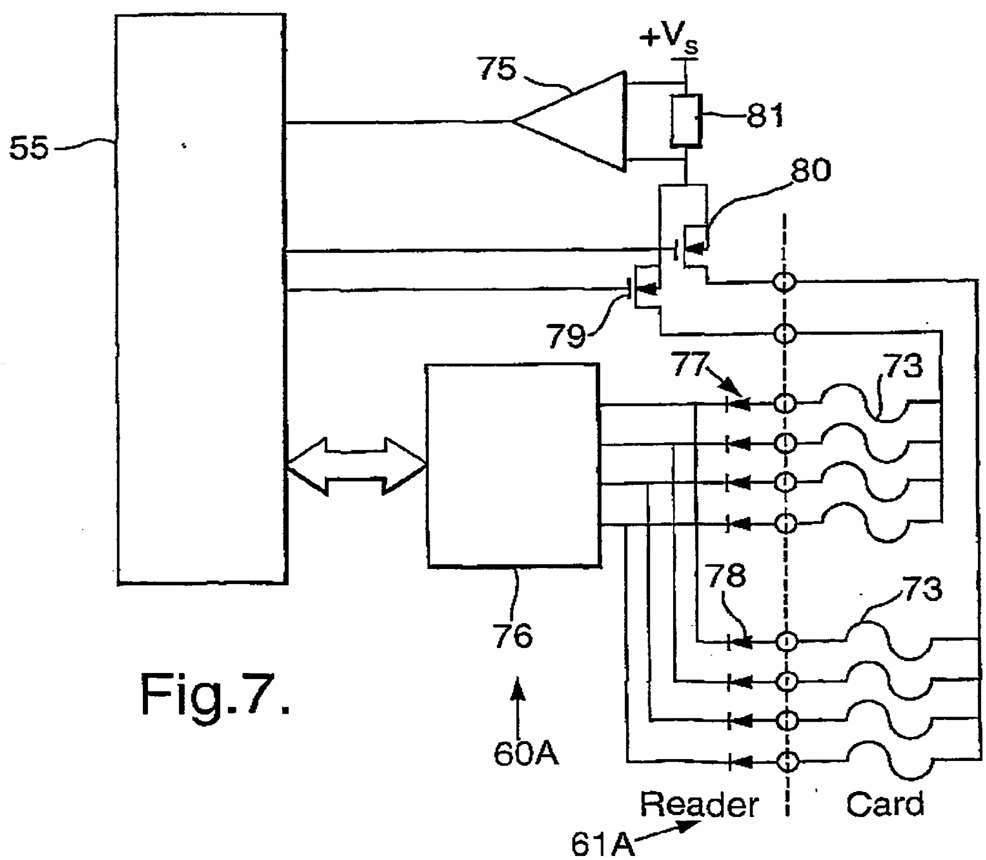

+Vs
75
81
55
80
79
77
73
78
73
76
60A
Reader
Card
61A

Fig.7.

Fig.8.

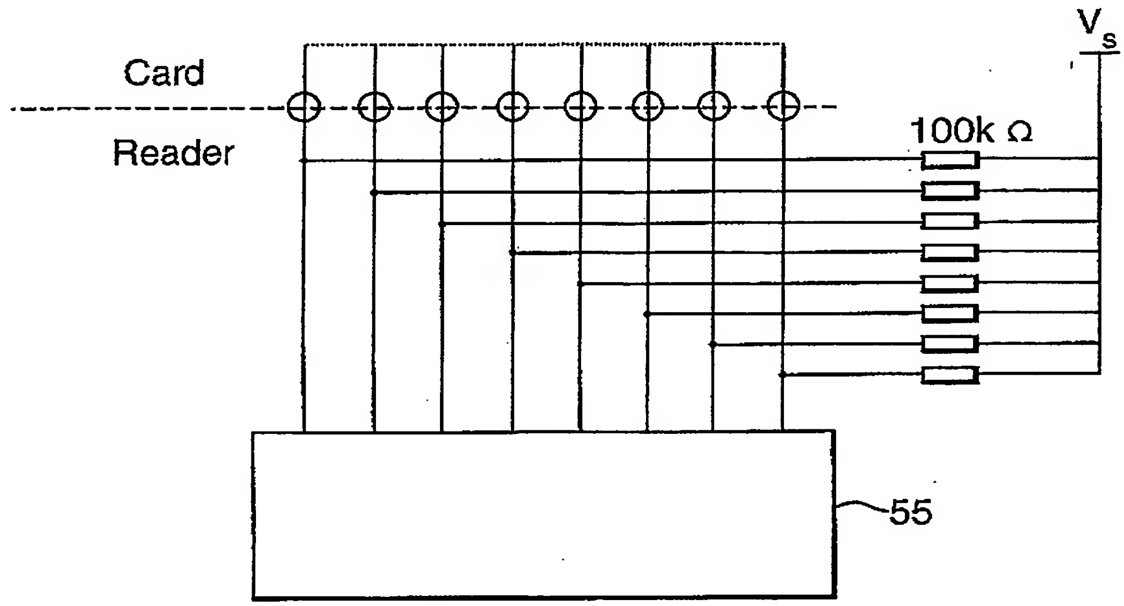


Fig.9A.

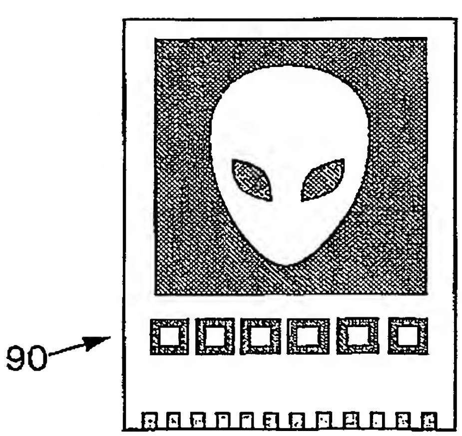


Fig.9B.

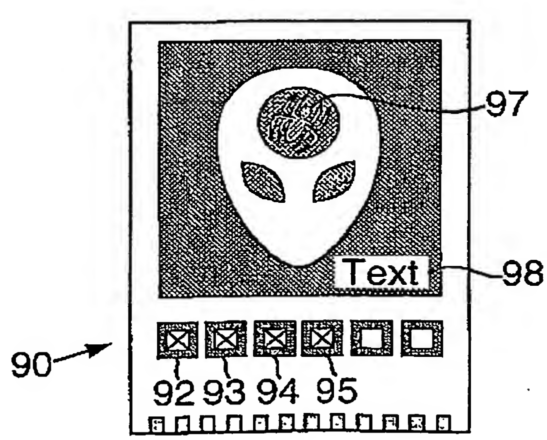


Fig.11B.

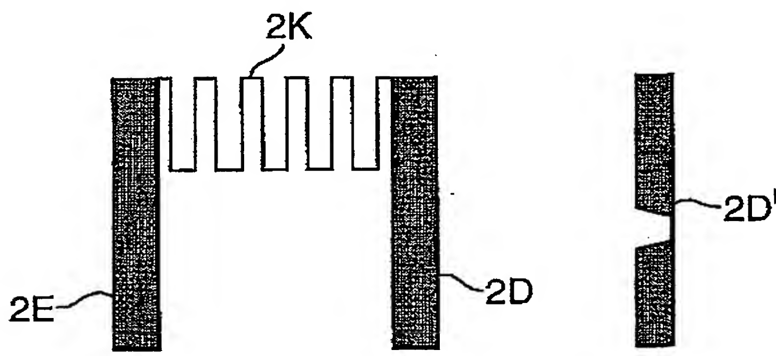


Fig.11A.

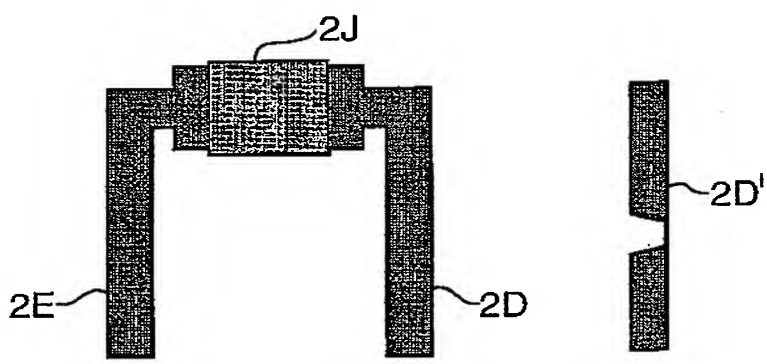
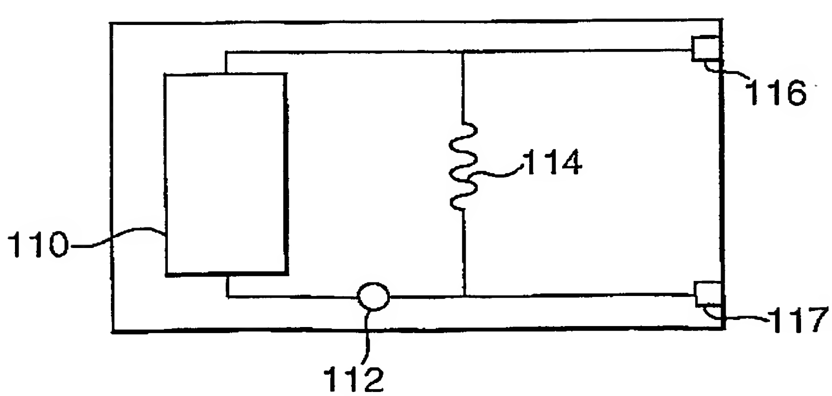


Fig.13.



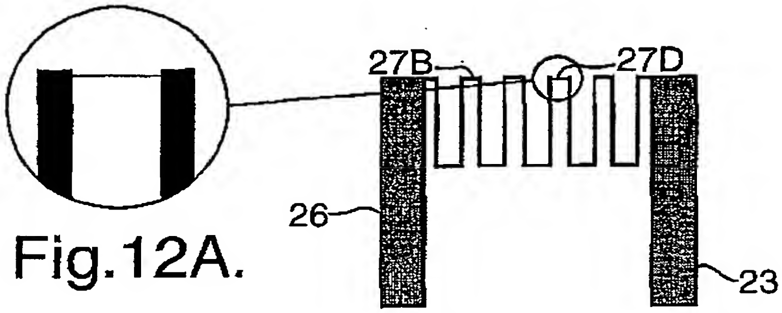


Fig.12A.

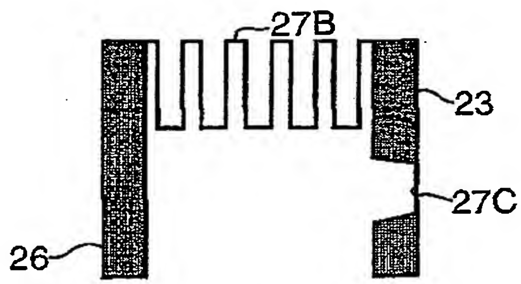


Fig.12B.

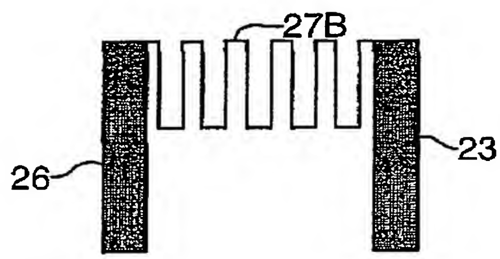


Fig.12C.

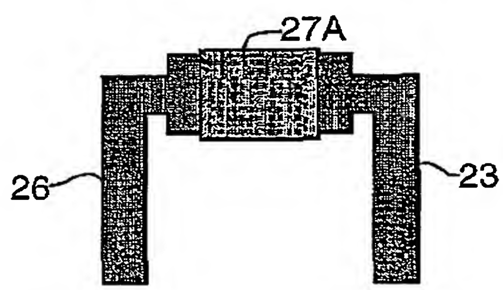


Fig.12D.

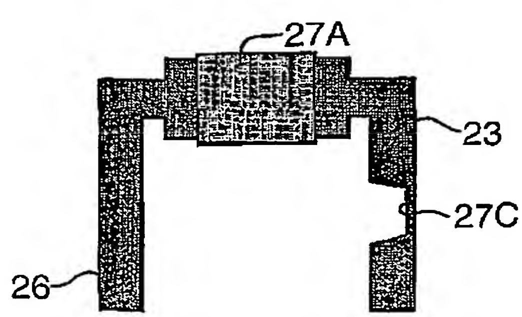


Fig.12E.

INTERNATIONAL SEARCH REPORT

PCT/GB 02/01694

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06K19/06 G07F7/08 A63F3/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06K G07F A63F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99 27414 A (ADACT LTD ;MARCO DORON (IL)) 3 June 1999 (1999-06-03) page 15, line 04 -page 17, line 02 page 72, line 03 -page 74, line 02 page 111, line 05 -page 114, line 16 page 34, line 01 -page 35, line 02 ---	11-36
X	WO 00 62248 A (LUSKI SHALOM ;NITZAN ZVI (IL); POWER PAPER LTD (IL)) 19 October 2000 (2000-10-19) page 3, line 03 -page 4, line 27 page 7, line 11 -page 8, line 14 page 11, line 26 -page 12, line 18 ---	1-36
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
19 July 2002	25/07/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Diot, P

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 5 621 200 A (DAIGLE STEVEN J ET AL) 15 April 1997 (1997-04-15) column 2, line 55 -column 3, line 65 column 32, line 27 -column 33, line 07	1-36
X	EP 0 426 163 A (TOKYO SHIBAURA ELECTRIC CO) 8 May 1991 (1991-05-08) column 6, line 03 -column 8, line 54	1-36
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X	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 05, 31 May 1999 (1999-05-31) -& JP 11 042874 A (EAST JAPAN RAILWAY CO;J R HIGASHI NIPPON MECHATRONICS KK), 16 February 1999 (1999-02-16) abstract	1-36
A	US 4 505 498 A (WEINBERGER ZVI) 19 March 1985 (1985-03-19) column 4, line 44 -column 6, line 09	1-36
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PCT/GB 02/01694

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